

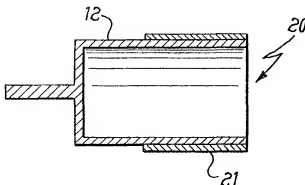
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(54) Title: HOLLOW CATHODE WITH INTEGRATED GETTER FOR DISCHARGE LAMPS AND METHODS FOR THE REALIZATION THEREOF



(57) Abstract: A hollow cathode (20; 30; 40) having at least a portion of the inner, outer or both surfaces coated with a layer of a getter material (21; 31; 41; 41') is described. Some methods for the production of the hollow cathode of the invention are also described.

- 1 -

"HOLLOW CATHODE WITH INTEGRATED GETTER FOR DISCHARGE
LAMPS AND METHODS FOR THE REALIZATION THEREOF"

5 The present invention relates to a hollow cathode with integrated getter for
discharge lamps, and to some methods for the realization thereof.

 There are defined as discharge lamps all the lamps in which the emission of
a radiation, that can be visible or ultraviolet, takes place as a consequence of the
electric discharge in a gaseous medium. The discharge is triggered and sustained
by the potential difference applied to two electrodes placed at the opposed ends of
10 the lamp.

 The cathodes for lamps can have various shapes, for example filaments or
spiral wound filaments, or other shapes. A particularly advantageous cathode form
is the hollow one: the hollow cathodes have generally the shape of a hollow
cylinder which is open at the end facing the discharge zone, and closed at the
15 opposite end. As it is well known in the field, a first advantage given by the
hollow cathodes with respect to other cathode shapes is a lower potential
difference (of about 5-10%) required to "light" the discharge; another advantage is
a lower intensity of the "sputtering" phenomenon by the cathode, namely the
emission of atoms or ions from the cathodic material that can deposit on adjacent
20 parts, among which the glass walls of the lamp, thus reducing the brilliancy
thereof. Examples of lamps with hollow cathodes are described for instance in
patents US 4,437,038, 4,461,970, 4,578,618, 4,698,550, 4,833,366 and 4,885,504
as well as in the published Japan patent application 2000-133201.

 In this field it is also known that, in order to assure a proper operation of a
25 lamp throughout its life, it is necessary to assure the composition consistency of
the mixtures forming the gaseous medium of the discharge. These mixtures are in
general mainly formed by one or several rare gases, such as argon or neon, and in
most cases some milligrams of mercury. The composition of these mixtures can
vary from the desired one, both because of the impurities remained in the lamp at
30 the production process, and of those released during time by the same materials
forming the lamp or permeating inward from the walls thereof. Impurities present

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in these mixtures can damage in various manners the working of the lamp: for example, oxygen or oxygenated species can react with mercury to form HgO, thus removing the metal from its function, while hydrogen can cause discharge striking difficulties (and consequently lighting difficulties of the lamp) or change the
5 operating electrical parameters of the lamp, increasing its energy consumption.

In order to eliminate these impurities it is known to introduce in the lamps a getter material. Getter materials have the function of fixing through a chemical reaction the impurities, thus removing them from the gaseous medium. Getter materials widely used to this purpose are for example the zirconium-aluminum
10 alloys described in patent US 3,203,901; the zirconium-iron alloys described in patent US 4,306,887; the zirconium-vanadium-iron alloys described in patent US 4,312,669; and the zirconium-cobalt-misch metal alloy described in patent US 5,961,750 (misch metal is a mixture of rare earth metals). These materials are generally introduced in the lamps in the form of getter devices formed by powders
15 of material that are fixed to a support. Usually, getter devices for lamps are formed by a cut down size of a supporting metal strip, flat or variously folded, onto which the powder is fixed by rolling; an example of getter device for lamps is described in patent US 5,825,127.

As it is known, although in some cases the getter device is formed by a
20 getter material pill simply inserted into the lamp, it is highly preferable when it is fixed to some constituting element of the lamp: the reasons are that a not fixed getter does not lie generally in the hot areas of the lamp, and so its gas absorbing efficiency decreases, and further it can interfere with the light emission. The device is accordingly almost always fixed (in general by spot welding), for
25 instance to the cathodic support, whereas in some cases a suitable support is added to the lamp: in all cases, however, additional steps are required in the production process of the lamp. In addition, there are lamps having an extremely reduced diameter, such as those used for backlighting the liquid crystal screens, which have diameters not larger than 2-3 millimeters; in this case it is difficult to find a
30 suitable arrangement of the getter device within the lamp, and the assembling operations for the device may become extremely difficult.

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An object of the present invention is to provide a hollow cathode for discharge lamps, which cathode fulfils the gettering function thus overcoming the above named problems.

This object is reached according to the present invention, that in a first
5 aspect relates to a hollow cathode formed by a hollow cylindrical part open at a first end and closed at the opposed end, in which on at least an outer or inner portion of the cylindrical surface a layer of getter material is present.

The invention will be described below with reference to the drawings wherein:

- 10 - Fig. 1 shows the section of the end part of a discharge lamp having a hollow cathode not coated with getter material;
- Figs. 2 to 4 show the sections of various possible embodiments of the hollow cathode according to the invention; and
- Fig. 5 shows a mode for obtaining a hollow cathode according to the
15 invention.

Figure 1 shows a section of the end part of a lamp 10 containing a hollow cathode 11 represented in its most general shape and without any coating formed of a getter layer. The cathode is made of metal and is formed by a cylindrical hollow part 12 having a closed end 13 and an open end 14. At end 13 there is
20 fixed a part 15 formed in general by a metallic wire; this part is generally fixed to the closed end of lamp 16, for example by inserting it in the glass when this is let soften by heat to allow the sealing of part 16. Part 15 fulfils the double function of a support of part 12 and of an electric conductor for connecting part 12 to the outside power. Parts 12 and 15 may form a single piece, but more generally they
25 are two parts fixed to each other for example by heat seal or mechanically by compression of part 12 around part 15.

Figures 2 to 4 show different embodiments of inventive cathodes, namely having a part of the surface coated with a getter layer. In particular figure 2 shows a hollow cathode 20 wherein a getter layer 21 is only present on a part of outer
30 surface of part 12; figure 3 shows a hollow cathode 30 wherein a getter layer 31 is only present on inner surface of part 12; finally, figure 4 shows a hollow cathode

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40 wherein two getter layers 41, 41' are present both on a portion of outer surface and on a portion of inner surface of part 12.

As it will be obvious to the skilled people, although in the figures only some embodiments have been represented, the coatings of the two surfaces (inner and
5 outer) of part 12 with a getter material can be total or partial: for example, in the case of figure 2, the layer 21 could totally coat the outer surface of part 12, or in the case of figure 4, a partial coating of inner surface, and total coating of outer surface, or any other combination of coatings could occur.

Part 12 is made in general of nickel or, according to the teaching of Japan
10 patent application 2000-133201, it can be formed with refractory metals such as tantalum, molybdenum or niobium, that show a reduced sputtering phenomenon.

The getter layer can be made of any one of the metals that are known to have a high reactivity with gases, which metals essentially are titanium, vanadium
yttrium, zirconium, niobium, hafnium and tantalum; among these the use of
15 titanium and zirconium is preferred. As an alternative, it is possible to employ a getter alloy, in general an alloy based on zirconium or titanium with one or more elements selected among the transition metals and aluminum, such as for instance the alloys of previously named patents.

The layer of getter material can have a thickness comprised between few
20 microns (μm) and some hundreds of μm , according to the technique used to produce it (as specified below) and according to the diameter of part 12: in the case of hollow cathodes in which part 12 has a diameter of about 1 millimeter, it is preferable that the thickness of the getter layer is as small as possible, in so far as the getter material is enough to effectively fulfil the function of absorbing the
25 gaseous impurities.

The layer of getter material does not alter the functionality of the cathode, as it was observed that these materials have work function values not exceeding those of the metals employed to produce part 12, and consequently the electronic emissive power of the cathode is not reduced.

30 In a second aspect, the invention relates to some methods for producing cathodes with a layer of getter material. According to a first embodiment, the

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layer of getter material can be produced by cathodic deposition, a technique better known in the field of thin layers production as "sputtering". As it is known, in this technique the support to be coated (in this case a hollow cathode) and a generally cylindrical body named "target", made of the material intended to form the layer,

5 are placed in a suitable chamber; the chamber is evacuated and then a rare gas, usually argon, is backfilled at a pressure of about 10^{-2} - 10^{-3} mbar; by applying a potential difference between the support and the target (the latter being kept at the cathodic potential) a plasma in argon is produced with formation of Ar^+ ions which are accelerated by the electric field towards the target, thus eroding it by

10 impact; the particles removed from the target (ions, atoms or "clusters" of atoms) deposit on the available surfaces, among which the ones of the support, forming a thin layer; for further details about principles and conditions of use, reference is made to the very abundant sectorial literature. The obtaining of a getter layer formed by a single metal, for example titanium or zirconium, can be achieved

15 with standard technical procedures. The production of alloy layers with this technique may result complicated owing to the difficulties encountered in producing a target of getter material, difficulties that can be overcome by having recourse to the targets described in international patent application WO 02/00959 in the name of the applicant. The productivity of the sputtering technique in terms

20 of layer thickness deposited in the time unit is not particularly high, so that this technique may become preferable when getter layers no more than about $20\text{ }\mu\text{m}$ thick are to be produced, and hence in the case of hollow cathodes with narrow diameter. Partial coatings of surfaces of part 12 can be obtained in this case by having recourse to masking, for instance by using, during the deposition,

25 supporting elements of part 12 that are suitably shaped and such as to selectively cover a portion of the surface thereof. An application example of such a measure is given in figure 5 regarding the production of a hollow cathode of type 40: in this case, during the deposition, part 12 is supported by an element 50 which masks a portion of both cylindrical surfaces (inner and outer) of said part; in the

30 figure the arrows indicate the coming direction of the particles of material to be deposited; at the end of deposition, the region free of deposited getter is used for

its fixing to part 15, whereas the region coated with getter is the one facing the lamp zone wherein the discharge occurs.

Another method for the production of a cathode coated with a getter layer according to the invention is by electrophoresis; the production principles of layers of getter material by this way are exposed in patent US 5,242,559 in the name of the applicant. In this case, as known, a suspension of fine particles of getter material in a liquid is prepared, and the support to be coated (part 12) is dipped in the suspension; by suitably applying a potential difference between the support to be coated and a subsidiary electrode (it also dipped obviously in the suspension), a transport of particles of getter material towards the support takes place; the so obtained deposit is then stiffened through heat treatments. In this case the partial or complete coating of part 12 can be obtained by simply partially or totally dipping said part in the suspension; in this case too it is further possible to selectively coat one of the two surfaces, inner or outer, by using a proper support of part 12, similarly to what previously explained in the case of element 50. This technique is fit to the production of thicker getter layers than those obtained by sputtering, with the possibility of easily and quickly forming layers having thickness up to some hundreds of μm .

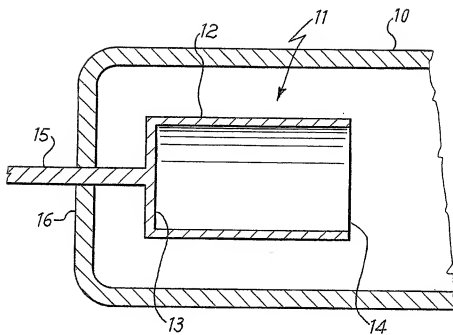
Finally, when part 12 is formed of a refractory metal such as described in Japan application 2000-133201, the coating can be carried out by simple dipping in a molten bath with a composition corresponding to that of the getter metal or alloy to be deposited; as a matter of fact, titanium and zirconium melt respectively at about 1650 and 1850 °C, and all previously cited zirconium-based alloys melt below 1500 °C, whereas molybdenum melts at about 2600 °C, niobium melts at about 2470 °C and tantalum at about 3000 °C, and it is thus possible to dip, without any change, parts made of these metals in molten baths of getter metals or alloys. In this case too, by totally or partially dipping part 12 in the bath, a partial or complete coating with the getter layer is obtained.

CLAIMS

1. A hollow cathode (20; 30; 40) formed by a cylindrical hollow part (12) closed at a first end (13) and open at the opposed end (14) in which on at least an outer or inner portion of the cylindrical surface a layer of getter material (21; 31; 41; 41') is present.
2. Hollow cathode according to claim 1, wherein said cylindrical hollow part is made of metal.
3. Hollow cathode according to claim 2, wherein said metal is chosen among nickel, molybdenum, tantalum or niobium.
4. Hollow cathode according to claim 1, wherein said layer of getter material is formed of a metal selected among titanium, vanadium, yttrium, zirconium, niobium, hafnium and tantalum or of an alloy based on zirconium or titanium with one or more elements selected among transition metals and aluminum.
5. A method for the production of a hollow cathode according to claim 1, wherein the layer of getter material is formed by cathodic deposition.
6. Method according to claim 5, wherein said layer of getter material has a thickness lower than 20 μm .
7. Method according to claim 5, wherein the partial coating of one or both inner and outer surfaces of said cylindrical hollow part occurs by masking said part during the cathodic deposition with a suitably shaped supporting element (50).
8. A method for the production of a hollow cathode according to claim 1, wherein said layer of getter material is formed by electrophoretic deposition.
9. Method according to claim 8, wherein the partial coating of one or both inner and outer surfaces of said cylindrical hollow part occurs by partially dipping said part in a liquid suspension containing getter particles used for the deposition.
10. A method for the production of a hollow cathode according to claim 3, wherein said cylindrical hollow part is made of tantalum, molybdenum or niobium, and the layer of getter material is formed by dipping said part in a molten bath of the getter metal or alloy of which the layer is to be made.
11. Method according to claim 10, wherein the partial coating of one or both inner

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and outer surfaces of said cylindrical hollow part occurs by partially dipping said part in said molten bath.

Fig. 1

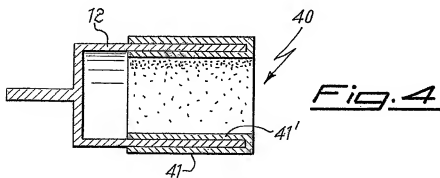
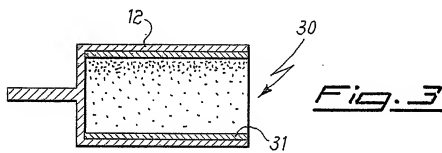
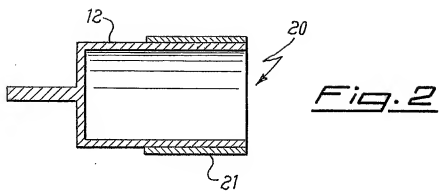
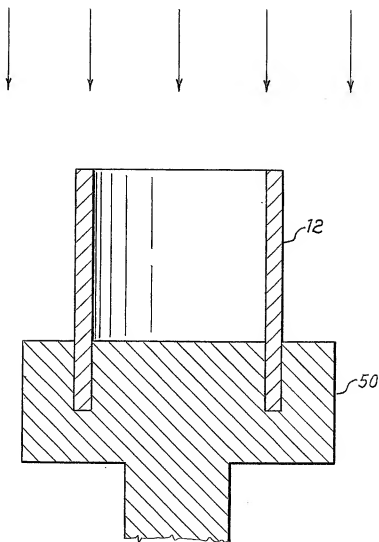


Fig. 5

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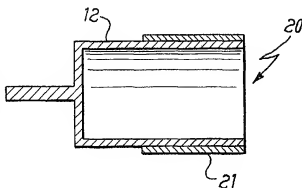
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(57) Abstract: A hollow cathode (20; 30; 40) having at least a portion of the inner, outer or both surfaces coated with a layer of a getter material (21; 31; 41') is described. Some methods for the production of the hollow cathode of the invention are also described.

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INTERNATIONAL SEARCH REPORT

Internat'l Application No
PCT/IT 02/00711

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 H01J61/09 H01J61/26 H01J7/18 H01J9/20		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 H01J		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, PAJ, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 675 520 A (OSRAM SYLVANIA INC) 4 October 1995 (1995-10-04)	1-4
Y	column 1, line 1 - line 26 column 5, line 46 - line 51 column 7, line 45 - line 47 claim 9; figure 1	5, 6
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 429 (E-1261), 8 September 1992 (1992-09-08), - & JP 04 149954 A (EREBAMU:KK), 22 May 1992 (1992-05-22)	1
Y	abstract; figure 2	4-6
-/-		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "Z" document member of the same patent family		
Date of the actual completion of the international search 15 January 2004		Date of mailing of the international search report 23.01.04
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 eponi Fax: (+31-70) 340-3016		Authorized officer Martin Vicente, M.

INTERNATIONAL SEARCH REPORT

Int Application No
PCT/IT 02/00711

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>DATABASE WPI Section Ch, Week 200034 Derwent Publications Ltd., London, GB; Class L03, AN 2000-392489 XP002254138 - & JP 2000 133201 A (HARRISON DENKI KK), 12 May 2000 (2000-05-12) cited in the application abstract; claims; figures paragraphs '0002!', '0016!', '0017!'</p>	1-6,8,9
Y	<p>US 4 628 198 A (GIORGI ETTORE) 9 December 1986 (1986-12-09) cited in the application column 6, line 42 - line 61 column 7, line 4 - line 5 ----</p>	1-6,8,9
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P,Y	<p>WO 02 45112 A (AMIOTTI MARCO ;GETTERS SPA (IT)) 6 June 2002 (2002-06-06) page 4, last line -page 5, line 13 ----</p>	4-6
P,Y	<p>WO 02 00959 A (GETTERS SPA ;TOIA LUCA (IT); BOFFITO CLAUDIO (IT); GALLITOGNOTTA A) 3 January 2002 (2002-01-03) cited in the application abstract page 1, line 15 - line 16 -----</p>	5

FURTHER INFORMATION CONTINUED FROM PCT/SA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-7

Hollow cathode with a getter layer and method for its production involving sputtering

2. Claim : 8 and 9

Electrophoretic deposition of a getter coating on a hollow cathode

3. Claim : 10 and 11

Production of a hollow cathode with a getter layer obtained by dipping in the molten getter material

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IT 02/00711

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 8.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
1-9

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims, it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter Application No
PCT/IT 02/00711

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
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